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Environmental Effects of Dredging Technical Notes

PLANT BIOASSAY OF DREDGED MATERIAL

PURPOSE: This note introduces the concept of using a plant as an indicator of the contaminants in dredged material. An example of the application of a plant bioassay procedure to saltwater dredged material placed in an upland disposal site was reported in a paper entitled "Contaminant Uptake by *Spartina alterniflora* from an Upland Material Disposal Site -- Application of a Saltwater Plant Bioassay," which was presented at the International Conference on Heavy Metals in the Environment in Heidelberg, Germany, and was published in the proceedings of the conference (Folsom and Lee 1983). The text of this note was taken from the paper.

BACKGROUND: Plant bioassay test procedures are being developed under the Long-Term Effects of Dredging Operations Program and are being field tested and verified under the "Interagency Field Verification of Testing and Predictive Methodologies for Dredged Material Disposal Alternatives," called the Field Verification Program (FVP). These procedures are relatively simple and can provide information that may be required in the ecological evaluation and environmental assessment of dredged material disposal. Based on laboratory results and limited field testing, the procedures can be applied to saltwater sediment or dredged material that requires placement in a wetland or upland environment. The concept presented in this note is the result of ongoing research under the FVP.

ADDITIONAL INFORMATION: Contact one of the authors, Dr. Bobby L. Folsom, Jr. (601) 634-3720 (FTS 542-3720) or Dr. Charles R. Lee (601) 634-3585 (FTS 542-3585), or the EEDP Program Manager, Dr. Robert M. Engler (601) 634-3624 (FTS 542-3624).

Introduction

Recently, a solid-phase plant bioassay was developed to test sediment for contaminants that are potentially phytotoxic and may be bioaccumulated by plants (Folsom and Lee 1981a; Folsom, Lee, and Bates 1981). The solid phase plant bioassay was shown to be an excellent tool for predicting whether or not

US Army Engineer Waterways Experiment Station, Environmental Laboratory
PO Box 631, Vicksburg, Mississippi 39180-0631

contaminants (e.g., zinc and cadmium) were potentially bioaccumulated by the saltwater plant *S. alterniflora*. Folsom and Lee (1981a) pointed out, however, that the DTPA extraction data indicated that plant uptake from air-dried oxidized saltwater sediment would be substantially greater than from the same saltwater sediment under flooded reduced conditions. In addition, they suspected greater plant uptake once the excess salts were leached out and the sediments were dried. This technical note reports results of modifications to the original solid-phase plant bioassay to pursue this assumption.

Methodology

A sediment from Black Rock Harbor (BRH) in Bridgeport, Connecticut, was selected for this study due to its extremely high concentrations of one or more contaminants. The sediment was analyzed for texture, salinity, organic matter, conductivity, calcium carbonate equivalent, pH, total sulfur, oil and grease, and heavy metals (total nitric acid digestible and DTPA extractable).

The solid-phase plant bioassay was conducted in an experimental unit similar to the one shown in Figure 1, which was used in earlier studies (Folsom and Lee 1981a). Procedures for the flooded condition were esentially the same as those used previously. The upland condition was prepared by washing one volume (1 ℓ) of original flooded sediment with three volumes (3 ℓ) of reverse osmosis (RO) purified water. An electric stirrer was used to mix the sediment and water; the solids in the resulting suspension were allowed to settle out (about 4 days); and the supernatant was siphoned off. The sediment was washed two more times using the same procedure, and then the washed sediment was air-dried.

The washed air-dried (upland) sediment to be tested was placed into the inner container of the solid-phase bioassay apparatus. Water of appropriate salinity (15 parts per thousand) was added to the flooded sediment. RO water was added to the air-dried sediment initially to moisten the sediment and to promote seedling growth. Additional water was added only to meet the needs for plant growth. From this point on, the procedure of Folsom and Lee (1981a) was followed with the exception that only *S. alterniflora* was grown as the index plant.

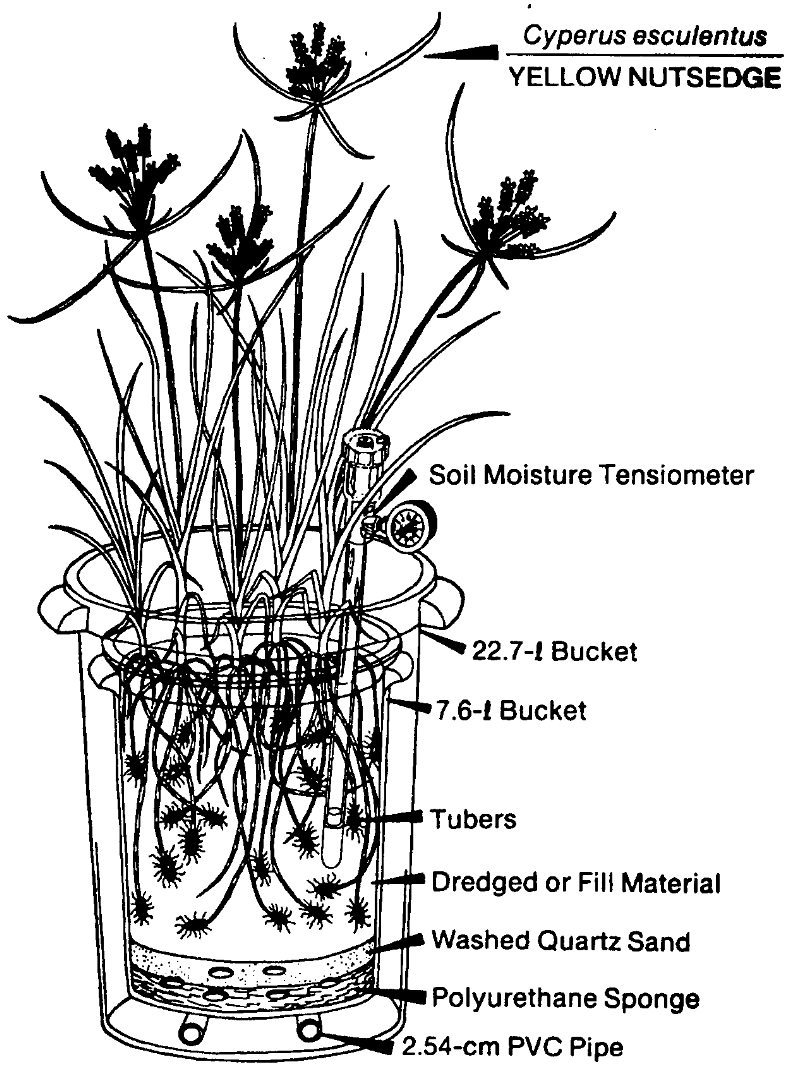

Figure 1. Schematic diagram of the experimental unit used for solid-phase plant bioassays

Results and Discussion

Selected physical and chemical parameters of the BRH sediment were determined to be as follows:

Organic matter, %	18.7
Salinity, ppt	25.3
Conductivity, dS/m	35.7
$CaCO_3$ equivalent, %	1.0
pH: wet	7.6
reconstituted air-dried	6.6
Oil and greese, mg/g	5.3
Total Sulfur, %	1.3

The total amounts and DTPA-extractable heavy metal concentrations in BRH sediment are shown in the following tabulation:

Heavy Metal	Concentration, μg/g			
	Total Acid Digestible-Original Sediment	DTPA Extractable		
		Original Sediment		Washed Sediment, Upland
		Flooded	Upland	
Zinc	1264	1.73	765	1017
Cadmium	16.7	<0.0005	22.0	24.7
Copper	2377	<0.005	701	235
Chromium	1346	0.18	1.45	1.62
Lead	330	0.01	14.3	23.2

The total sediment content of heavy metals was typical for that of contaminated saltwater sediment with the exception of copper, which was much greater (Folsom, Lee, and Bates 1981).

The data for the DTPA-extractable heavy metals in the BRH sediment showed that air-drying resulted in increased heavy metals extractability. Washing the sediment before air-drying had only a slightly increased effect on DTPA extractability of the heavy metals. The DTPA data would predict plant uptake of heavy metals to be greater from the air-dried upland sediment compared to the original flooded sediment.

Contents of the heavy metals in the leaf tissues of *S. alterniflora* grown in original sediment under both flooded and upland conditions and in upland washed BRH sediment are presented below:

Heavy Metal	Concentration, μg/g		
	Original Sediment		Washed Sediment, Upland
	Flooded	Upland*	
Zinc	13.0	219	341
Cadmium	0.04	0.91	4.65
Copper	3.77	18.7	36.2
Chromium	0.02	0.93	2.79
Lead	0.39	1.53	2.53

* Only one replicate supported plant growth.

Spartina alterniflora grew well and had low heavy metal contents under the flooded conditions. These results are typical for contaminated saltwater sediment placed under a flooded condition, and the data compared well with levels observed in plants from natural saltmarshes (Simmers et al. 1981). *S. alterniflora* did not grow well in the original air-dried (upland) sediment:

only one plant of one replicate survived. Decreased plant growth resulting in increased metal content could explain the elevated heavy metal content of the plant. Plants grown in washed sediment under an upland condition grew much better than under the unwashed upland condition. However, the heavy metal content of the plants was much greater compared to that of plants grown in the flooded condition. The same effect has been shown by Folsom and Lee (1981b) to occur with freshwater plants grown in freshwater sediment under flooded and upland disposal environments. Apparently, once the saltwater sediment is washed free of excess salt and plant growth occurs, the air-drying process results in increased availability of heavy metals. Removing excess salt from the sediment by washing simulated the natural salt-leaching process and can be used in a modified saltwater solid-phase plant bioassay to predict contaminant mobility into plants growing on saltwater dredged material deposited in upland disposal sites.

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US Army Engineer Waterways Experiment Station
Environmental Laboratory
PO Box 631
Vicksburg, Mississippi 39181-0631

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